# offline level2 muon trigger for Run4 *fast* analysis

- introduction
- principle and cuts
- rejection power
- reconstruction time (level2 vs minimum bias)
- efficiency

## Requirements on level2 triggers

- fast (less than 30ms/event) to run online;
- selective, as all trigger do, especially for rare events;
- efficient, not to lose signal;
- work stable in the DAQ; compile under Windows.

## Initial plans for RUN4

- validate and re-use RUN2 muid level2 trigger;
- use an additional mutr trigger on top of muid trigger;
- use level2 triggers online to tag events;
- downscale the minimum bias trigger to ensure highest lifetime on level2 triggers.

## Present situation

- level2 triggers have not been used online;
- RUN2 muid trigger is used offline for a fast muon analysis, to
  get *fast* preliminary results
  validate/anticipate the minimum bias analysis;
- RUN4 additional mutr trigger is not used.

# Principle and cuts [I]: Muid level2 trigger

## Muid trigger basic tracking

- using OR of tubes in gaps to make *symsets* (groups of tubes)
- using AND of different gaps (same panels) with rough target pointing
- combine horizontal and vertical roads and fit (straight line)

## Muid trigger event selection

- keep roads with slope $\geq 12^{o}$
- keep events with (at least) two roads with opening angle $\geq 19.2^{o}$
- keep events for witch road candidates pass depth selection

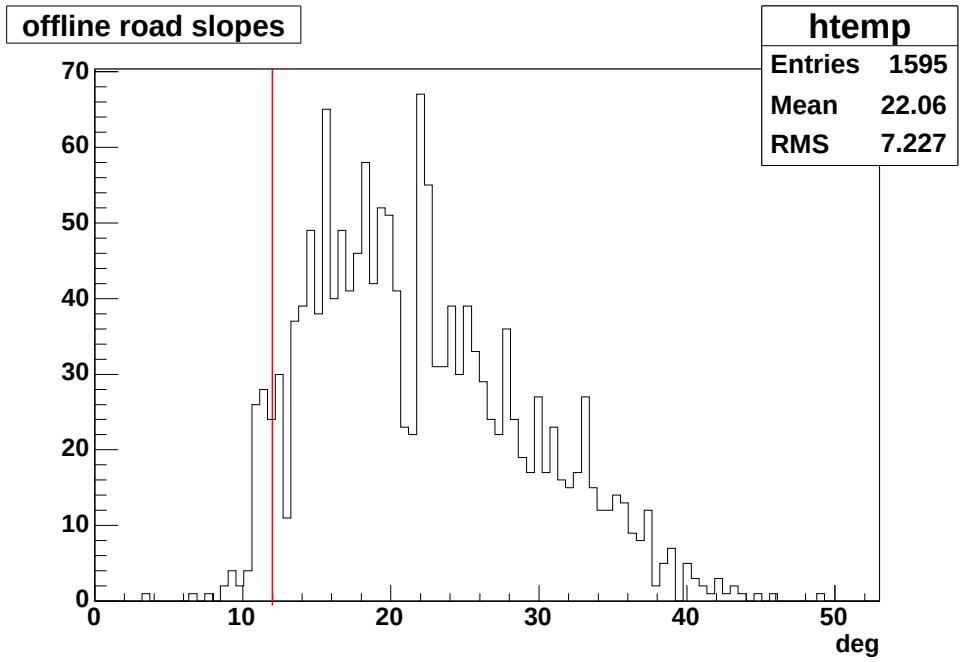
| | |
|---|---|
| shallow shallow | both road depth $\geq 2$ |
| deep shallow | one road $\geq 4$ the other $\geq 2$ |
| deep deep | both road depth $\geq 4$ |

Note: depth counting starts from 0, i.e. first gap = depth 0

- additional cut on #hits/road depending on depth: for deep roads $N_{\text{hits}} \geq 8$

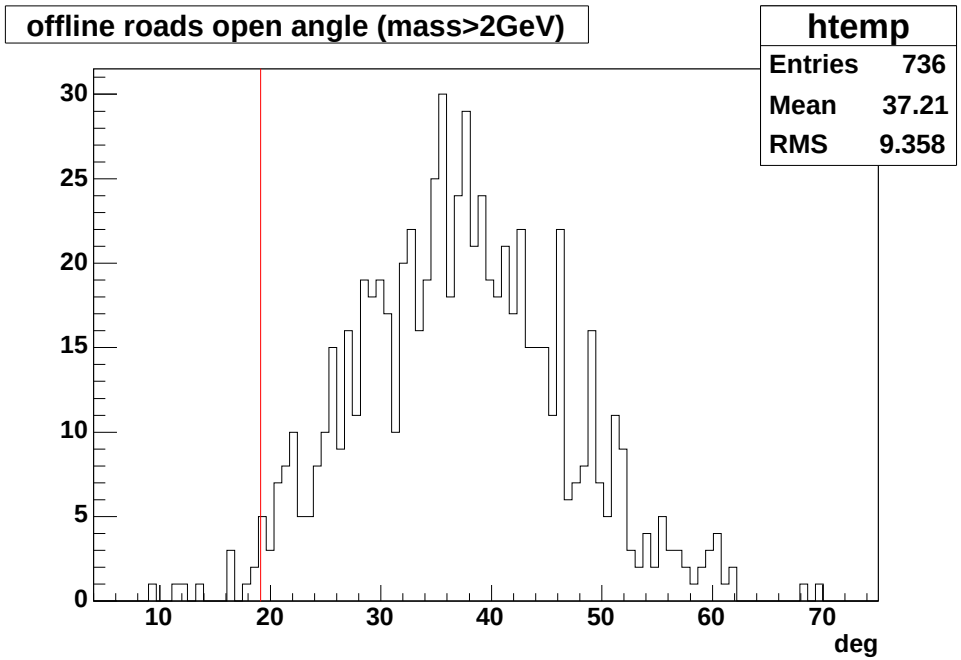
# Muid level2 road slopes and open angle on MC

## single road slope




## road pairs open angle

(in mass window 2 to 5 GeV)



# Principle and cuts [II]: Mutr level2 trigger (not used for RUN4)

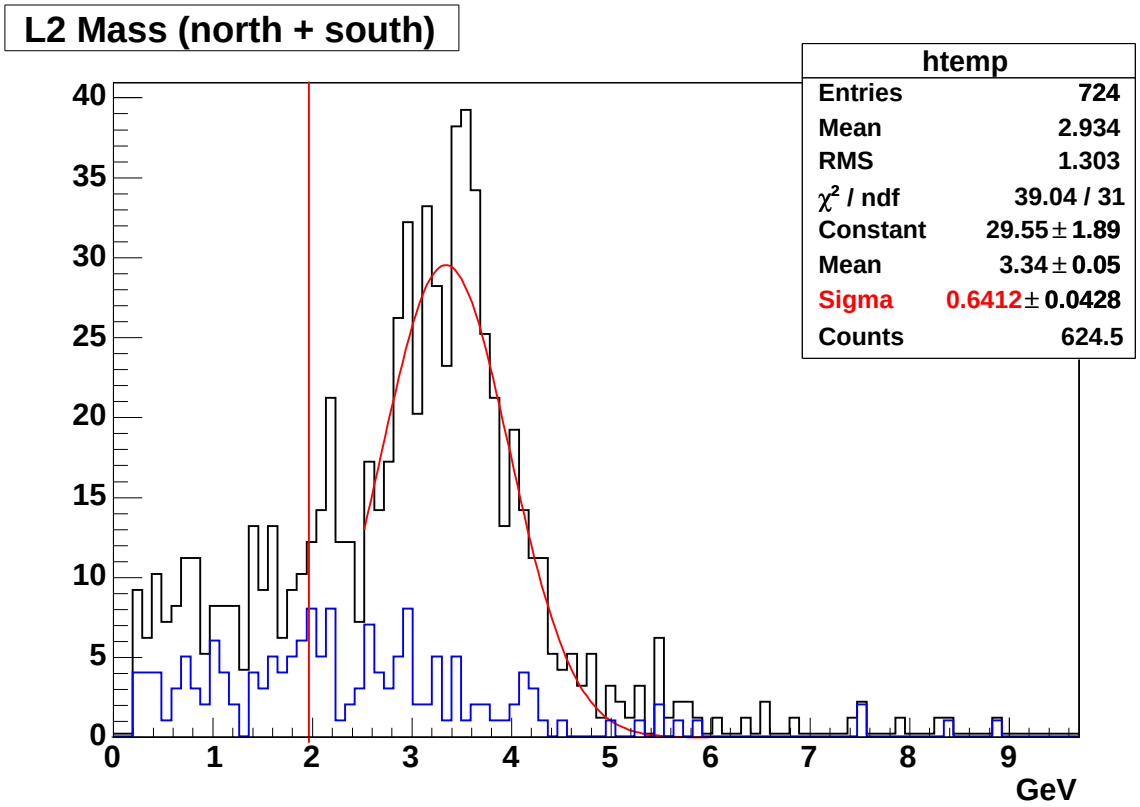
## Mutr trigger basic tracking

- extrapolate road to station 3 in mutr, find best matching *gap coordinate*, if any;
- extrapolate to station 2 in mutr, find best matching *gap coordinate*, if any;
- use parametrized lookup table to calculate track momentum

## Mutr trigger event selection

- select roads matching $(\theta, \phi)$ cuts at stations 2 then station 3;
- keep events accepted by Muid trigger + calculated mass for dimuon candidates $\geq 2$ GeV

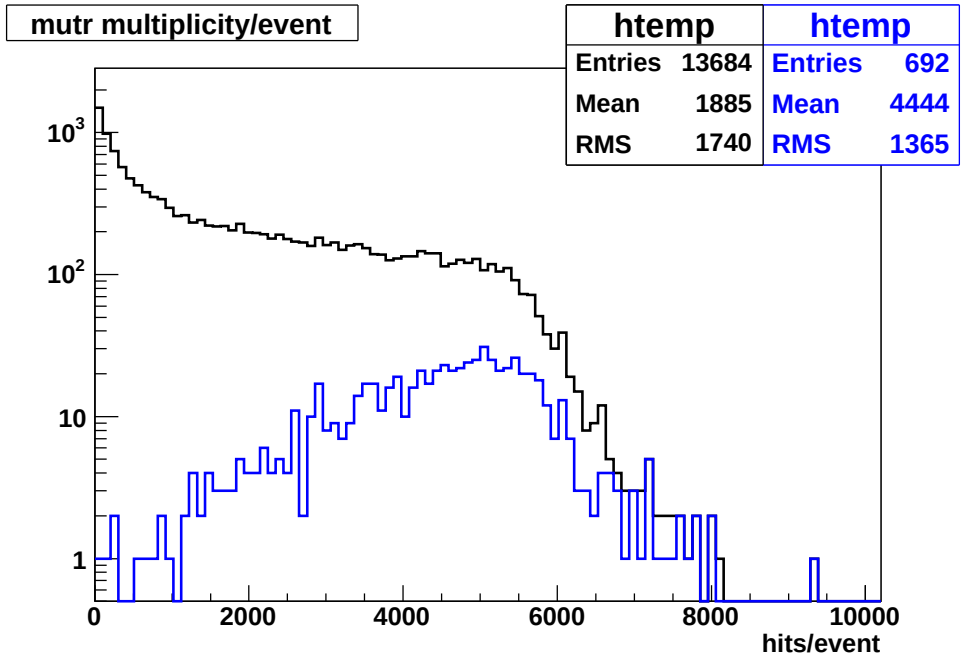
# Mutr level2 mass distribution on MC

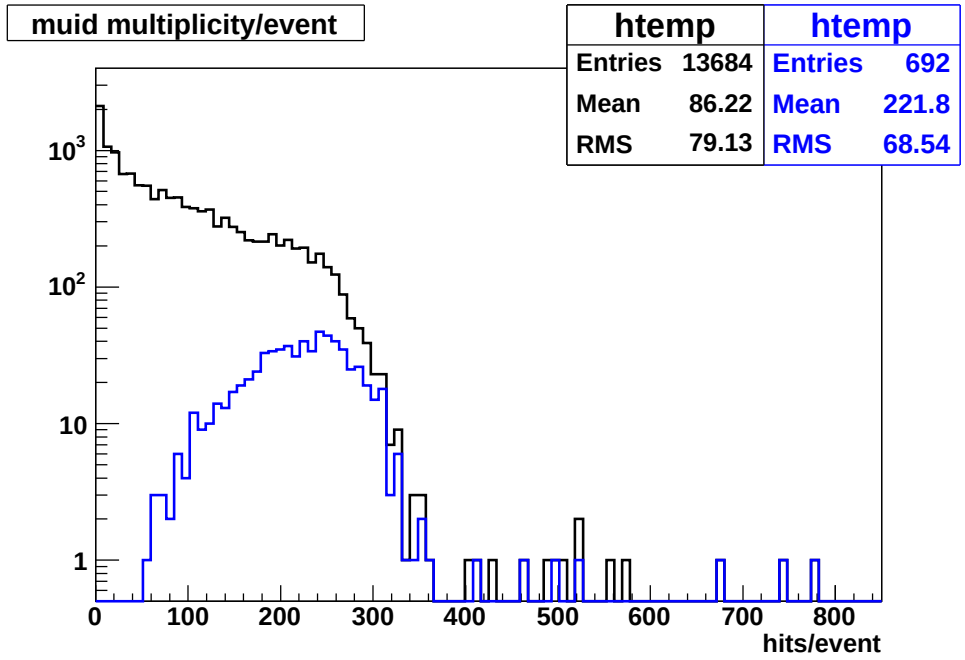



- Additional time on top of muid trigger: $\sim$ 5ms/event;
- Additional rejection factor: $\sim \times 2$ wrt muid trigger;
- but no time to get confidence in trigger efficiency on RD.

**$\Rightarrow$ mutr level2 trigger not used for RUN4 *fast* analysis**

# What level2 does to our data [I]: hit multiplicity

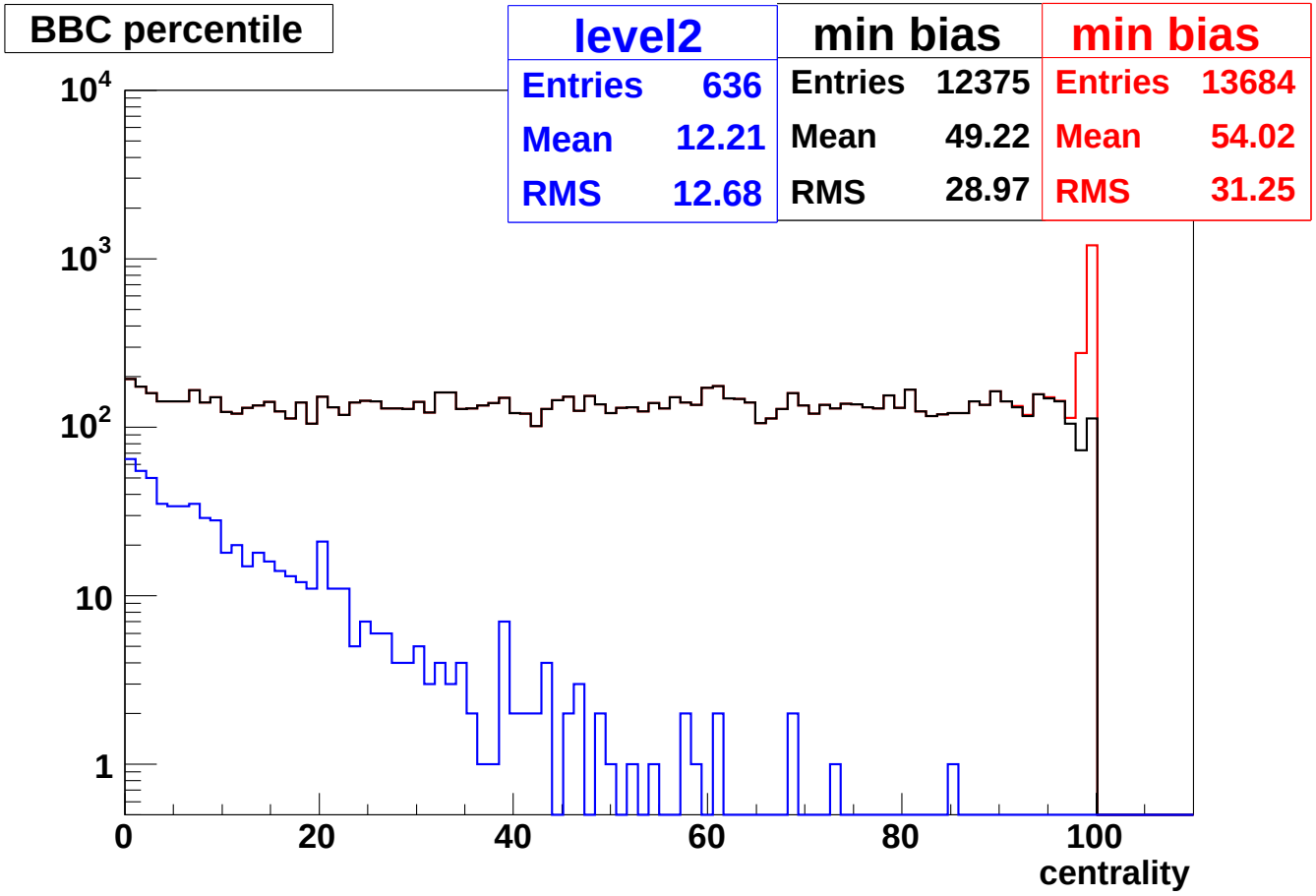



black: minimum bias events

blue: level2 filtered events

# What level2 does to our data [II]: *recalibrated* BBC centrality




(*recalibrated* from BBC charge distribution @200GeV)

# Rejection power and timing

## Level2 muid trigger on Run4 real data sample

| depth | north | south |
|---|---|---|
| shallow shallow | 4 | 4 |
| deep shallow | 9 | 9 |
| deep deep | 40 | 36 |

$$\text{rejection power} = \frac{N_{\text{minbias}}}{N_{\text{L2accepted}}}$$

## Level2 and offline timing on Run4 realdata sample

| | minimum bias | level2 filtered |
|---|---|---|
| Average time/event in lvl2 reco | - | 51 ms |
| Average time/event in offline reco | 1200 ms | 5600 ms |
| Total time for one segment | $1.6 \times 10^7$ ms | $3.6 \times 10^6$ ms |

**$\Rightarrow$ filtered reconstruction $\sim$ 3 to 4 times faster (here 4.4)**

# Level2 efficiency analysis chain [I]

## principle

- embed

  MC J/$\psi$ signal with realistic muid/mutr efficiencies

  minimum bias RUN4 real data

- run level2 and offline (MuTOO, MuiOO) reconstruction
- build evaluation ntuples for

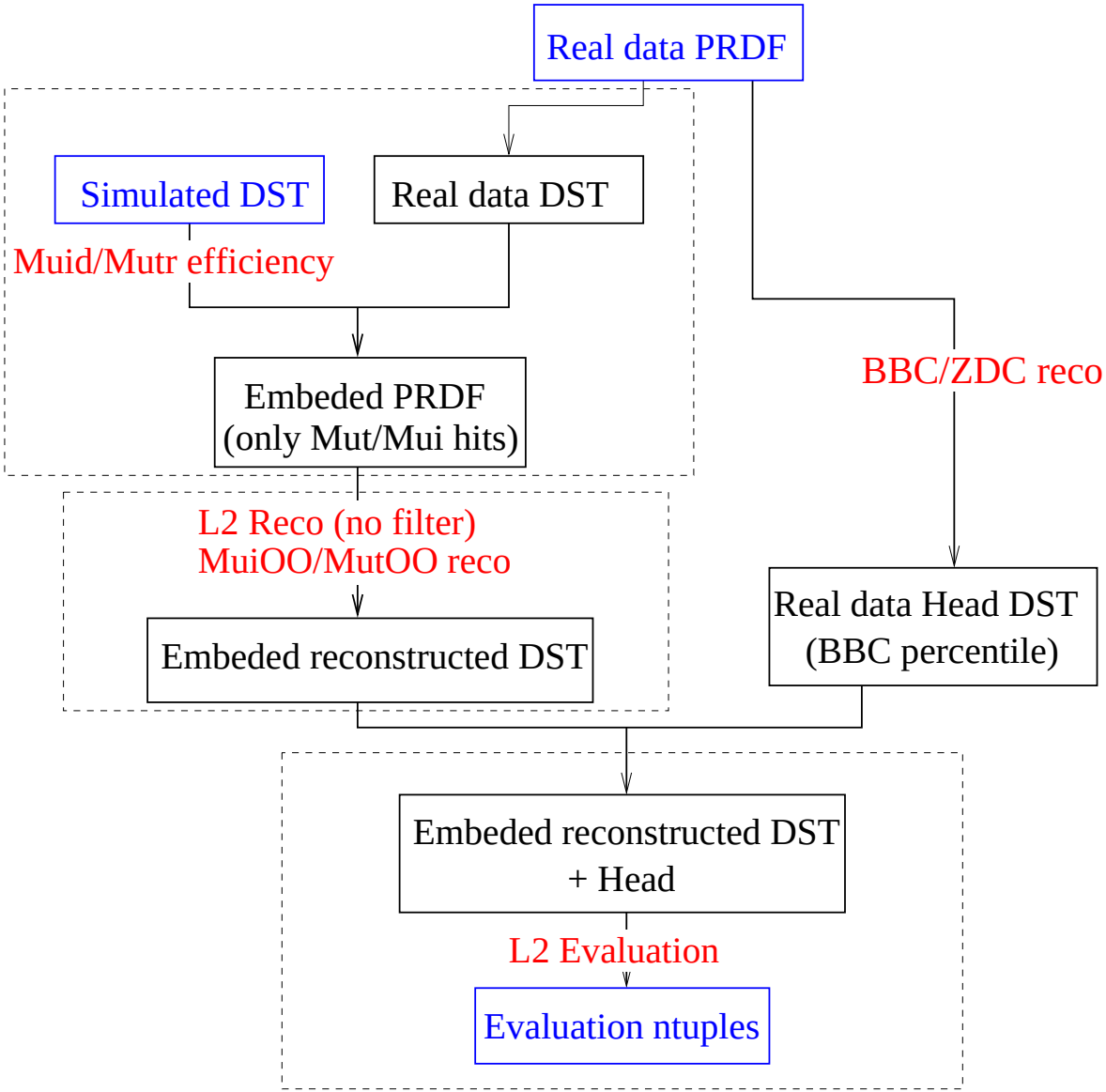
  absolute level2 efficiency

  level2 efficiency wrt offline

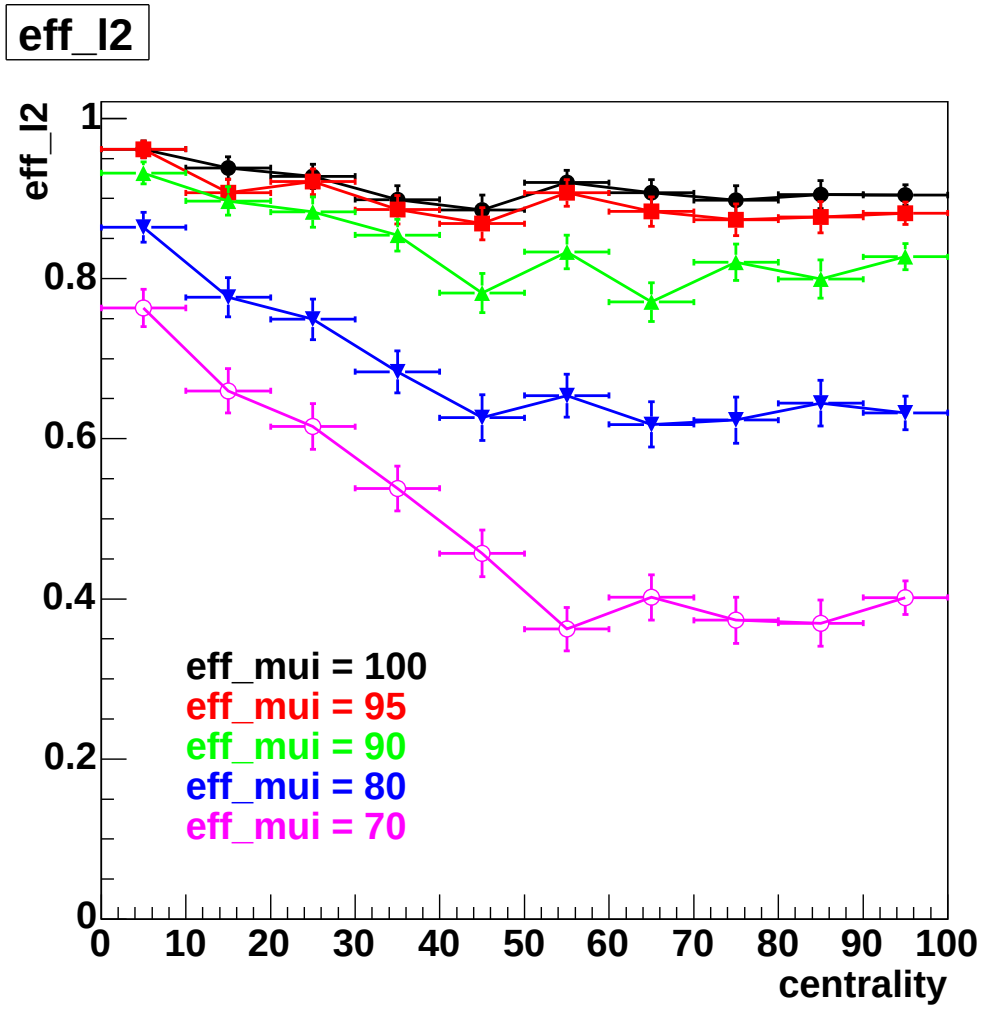
## problems/technical issues

- level2 framework runs only on PRDF
- PRDF embedding cannot be done directly in new framework (need DST stage)
- PRDF generation/merging in new framework erase global detectors (BBC)

# level2 efficiency analysis chain [II]



# Level2 efficiency vs muid efficiency

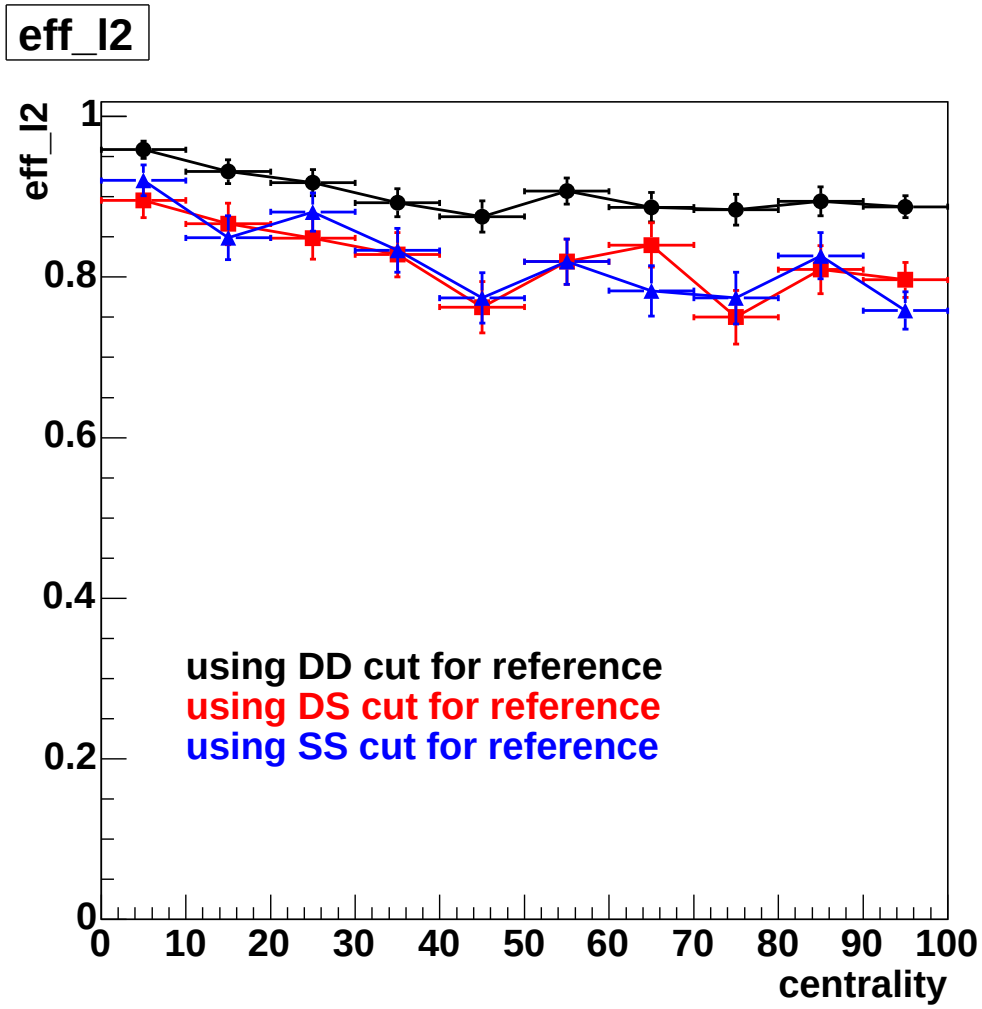



**average efficiency:**

| muid (%) | level2 (%) | |
|---|---|---|
| | pure MC | embedded |
| 100 | 90 | 92 |
| 95 | 87 | 90 |
| 90 | 81 | 84 |
| 80 | 59 | 69 |
| 70 | 35 | 49 |

using 3k Deep-Deep MC J/$\psi$ embedded in RUN4 real data

# Level2 efficiency for realistic RUN4 muid efficiency (run 109656)




**muid efficiency/gap:**

| gap | 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| south arm | 97.5 | 96.5 | 96.6 | 97.1 | 96.5 |
| north arm | 97.5 | 95.9 | 95.9 | 97.2 | 96.0 |

average = 96.7 %

**average level2 efficiency:**

| depth cut on MC | level2 (%) |
|---|---|
| deep deep | 90.3 |
| deep shallow | 82.0 |
| shallow shallow | 81.8 |

using 3k pythia J/$\psi$ embedded in RUN4 real data

# Level2 efficiency vs offline reconstruction

## principle:

- run both level2 and offline reconstruction on all events
- put strict selection on offline to define *offline accepted events*
- get the fraction of such events accepted by level2

## advantage:

- can run both on MC and RD;
- if cuts on offline are strict enough, should give the same result;
- validates MC/embedded studies for *absolute* efficiency.

## problems:

- efficiency level2 vs offline on MC $\sim 95\%$;
- on RD (using same *strict* cuts) 75 to 80%;
  - $\rightarrow$ low statistic on RD due to strict cuts;
  - $\rightarrow$ unknown amount of remaining ghosts from offline reconstruction.

# Conclusion

- overall level2 efficiency:
  - $\sim$ 90 % for embedded deep deep J/$\psi$
  - $\sim$ 82 % for embedded pythia J/$\psi$
- efficiency increase for central events (random benefit)

## Todo:

- understand/fix discrepancy on level2 efficiency vs offline
- include mutr efficiency and run full chain to get combined level2/offline absolute efficiency